In-Space Propulsion Engine Architecture Based on Sublimation of Planetary Resources: From Exploration Robots to NEO Mitigation

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Purpose of this NIAC study

Identify those volatile and mineral resources that are available on asteroids, comets, moons and planets in the solar system, and investigate methods to transform these resources into forms of power that will expand the capabilities of future robotic and human exploration missions to explore planetary bodies beyond the Moon and will mitigate hazards from NEOs.

Power for Exploration Systems

The sources of power used for deep space probe missions are usually derived from either solar panels for electrical energy, radioisotope thermal generators for thermal energy, or fuel cells and chemical reactions for chemical energy and propulsion.

Figure 1. Concept for utilizing a comet's frozen resources to provide cold propulsion and deflect it from a potential collision with Earth.

Applications of sublimated gas in planetary missions

• Pneumatic Conveying of Regolith: 500 grams of CO_2 ice sublimated into gas at 10 psig would convey 5 Kg of regolith in one minute.

• Attitude-control thruster: a 3.6N thruster would require 71 Kg of CO_2 per minute.

• Near Earth Asteroid deflection: Deflecting a C-type asteroid by providing a Δv of 1m/s in one day requires ejecting 4×10^{-6}% of its mass at 3m/s during that time. This means 660 Kg of material must be ejected per second for one day to deflect a 400m C-type asteroid.

Ice types and quantities estimated in various locations of the solar system

Location	Ice Type	Pressure (Torr)	Temperature (K)
Moon	H_2O	10^{-14}	40 - 100
Mars	H_2O, CO_2	4.5	150
Comets	H_2O, CO_2	10^{-14}	40
Europa	H_2O, CH_4, CO_2	10	100
Titan	H_2O, CO_2	1,140	150

Planetary Resources

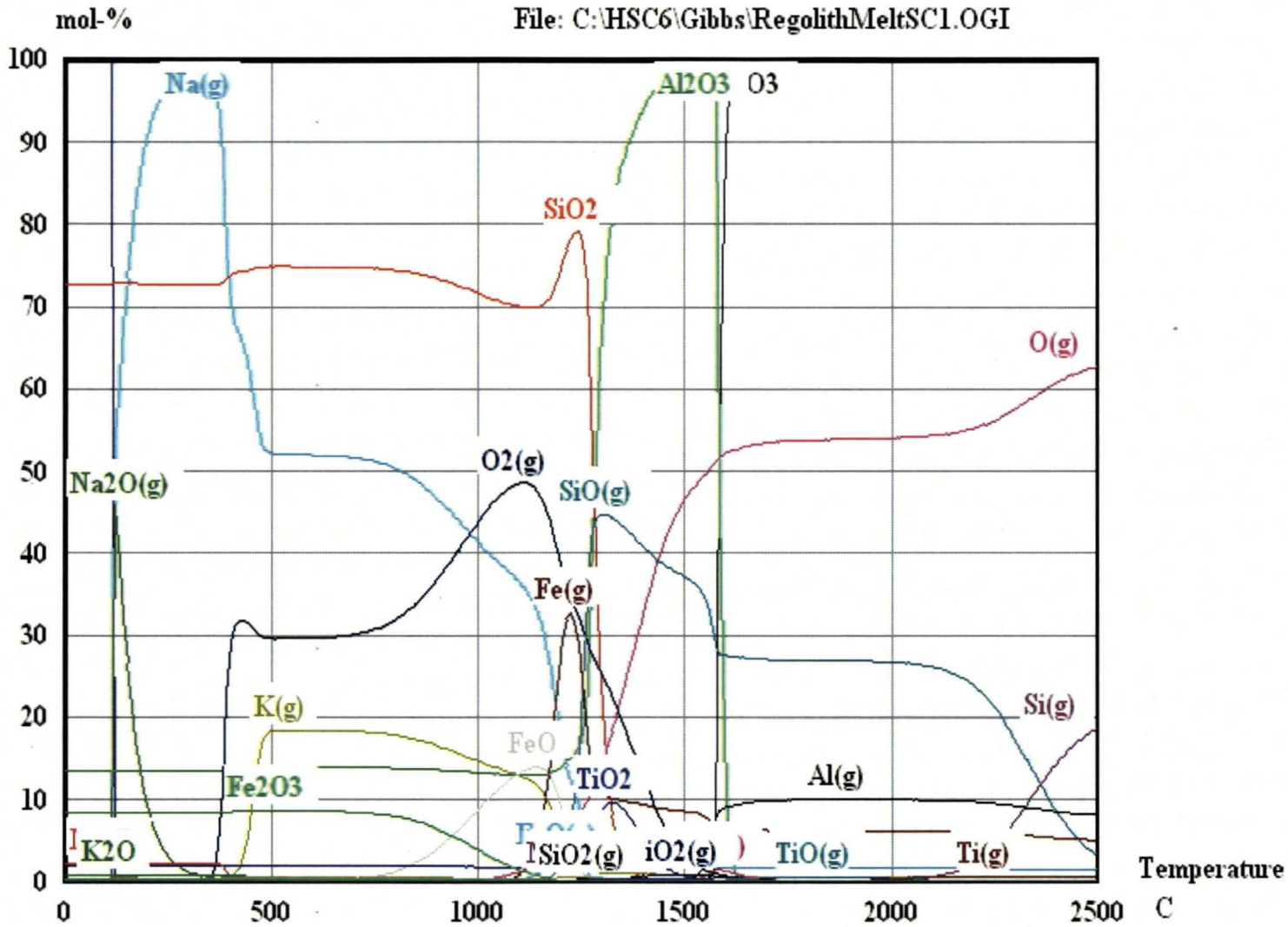
The surface materials found on asteroids, comets and terrestrial moons and planets consist mainly of minerals composed of metal oxides, but they also contain ices of substances such as water and carbon dioxide all of which can be vaporized thermally into gases at moderate temperatures due to low atmospheric pressure conditions.

Phase 1 Goals

This initial NIAC study will focus on verifying the assumptions currently made about the properties of solid volatile ices found throughout the solar system, and demonstrating through experiments how much gaseous material can be produced from them to provide useful mechanical power for such activities as lifting objects using actuators and for providing cold gas propulsion.

The work will also investigate new engineering concepts for using the gasification of ice and mineral rocks found inside asteroids and comets in order to divert their path away from a potential collision course with Earth.

Sublimation of silicates from asteroids at pressure 10^{-7} torr



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